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REACTION TO FIRE – SBI TEST

Snežana Ilić [1] Mirjana Laban [2] Igor Džolev [3]

Abstract: The fire reaction represents the behavior of materials during a fire event, i.e., how much the material contributes to the fire development. The importance of determining the fire reaction class stems from the need to provide sufficient time for the individuals inside a building to evacuate safely in the event of a fire. The fire reaction class is determined through a series of tests, depending on the material, with the most significant test in this group being the SBI (Single Burning Item) test. The paper describes the preparation method of test samples, the testing procedure itself, as well as the output data used for determination of the fire resistance class for tested material. According to the SRPS EN 13823 standard, a sample of a multilayered facade system with mineral wool was tested. The testing process itself, as well as the processed results, are stated in the conclusionof the study.

Key words: reaction to fire, SBI test, facade system with mineral wool, experiment, classification

1. INTRODUCTION

The duration of fire depends on several factors, such as the fire load, the size and ventilation properties of the fire compartments, and the amount of combustible materials in the building [1]. This is the reason why designers should pay more attention when choosing materials for buildings. The standard SRPS EN 13501-1 [2] is developed for the classification of building materials. The standard prescribes three parameters for classification: a main classification related to heat production (classes A1, A2, B, C, D,E or F, where A1 represents the highest level -no contribution to fire, and F has no requirements or -no performance determined), and additional classifications for smoke production (s1, s2 or s3, where s1 is the best, s3 has no requirements) and leaking of materials on the surface fire exposure - flaming droplets and particles (d0, d1, d2, where d0 is the best, d2 has no requirements) [3]. Depending on the required class, several tests should be completed. There are five, standardized methods for determining the class for reaction to fire (Table 1):

- SRPS EN ISO 1182 – non-combustibility test,
- SRPS EN ISO 1716 – test for determination of calorific value,
- SRPS EN 13823 – single burning item test,
- SRPS EN 11925-2 – ignitability test.

Table 1 – Classification for construction products excluding floorings and linear pipe thermal insulation products [1]

Class	Test methods	Additional classification
A1	EN ISO 1182 and EN ISO 1716	-
A2	EN ISO 1182 or EN ISO 1716, and EN 13823	s1, s2, s3 d0, d1, d2
B	EN 13823 or EN ISO 11925-2	s1, s2, s3 d0, d1, d2
C	EN 13823 or EN ISO 11925-2	s1, s2, s3 d0, d1, d2
D	EN 13823 or EN ISO 11925-2	s1, s2, s3 d0, d1, d2
E	EN ISO 11925-2	without additional classification/d2
F	EN ISO 11925-2	-

[1] MSc, Institute IMS, Belgrade, Bulevar Vojvode Mišića 43, snezana.ilic@institutims.rs
[2] PhD, Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, e-mail: mlaban@uns.ac.rs
[3] PhD, Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, e-mail: idzolev@uns.ac.rs

The most important and complex test, from the list, is the single burning item test (SBI test). This is the main reason why this test is chosen for the research and experiment.

2. TEST METHOD

For the development of this research, the test used is the SBI test, which is a test method developed to determine the reaction behavior of construction products (except floors) when exposed tofire through a thermal attack by a single item of burning [4]. The SBI test was developed by a group of European fire laboratories on the basis of the specifications defined by a group of European fire regulators. [5] The aim was to develop a test method that produces results representative for the behavior of building products when exposed to one single object, e.g. a coach or a litter basket, on fire placed in the corner of a room [3].

The SBI test consists of a test room, test apparatus, smoke exhaust system, and measurement equipment. The test apparatus consists of a trolley, frame, burners, hood, collector, and ducting. Figure 1 shows the apparatus for SBI test (the first picture represents the equipment mounted in the Laboratory for thermal technique and fire resistance at the Institute IMS in Belgrade, and the second figure shows the parts of the equipment [3].

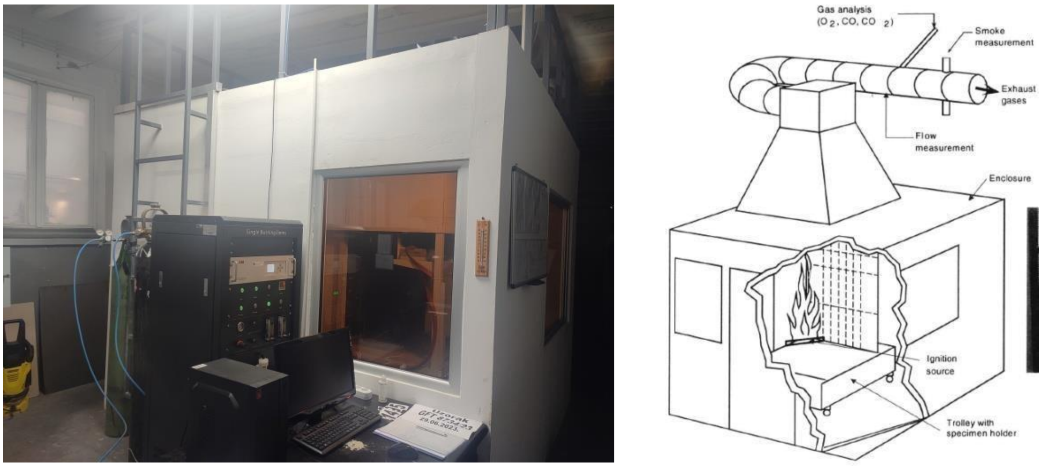

Figure 1 – Apparatus for SBI test

This test begins with exposing a sample to a flame propagated by a burner supplied with propane gas, through which it is possible to conduct visual or instrumental analysis: instrumentally, the rates of release of heat and smoke are measured, and visually it is possible to observe the physical characteristics of the sample when directly subjected to the flame [4]. The dimensions of the test room are specially prescribed in the standard SRPS EN 13823 [2]. The inner height of the test room shall be (2.4 ± 0.05) m, and the inner floor area of the test room shall be (3.0 ± 0.05) m in both directions. The walls of the test room should be made of materials with class A1. The room has to havetwo windows for observing, one door for handling the SBI apparatus and the specimen when the trolley is in the place for testing. One wall of the test room has to have an opening for inserting the trolley with dimensions (1470 x 2450) mm (W x H). The role of the trolley is to fix and prepare the specimen wings for testing. In the corner, the trolley has the sandbox (the main (primary) burner). The specimen consists of two wings (short wing and long wing) forming a right-angled corner. The dimensions of the short wing are (495 ± 5) mm x (1500 ± 5) mm, and the dimensions of the long wing are (1000 ± 5) mm x (1500 ± 5) mm. A frame for the trolley supports the hood, which is made for collecting the combustions gases. Above the hood, there is a collector with an exhaust duct linked to a ventilation inlet [5]. The smoke exhaust has two side ducts and is capable of extracting a volume flow of 0.50 m^3 to 0.65 m^3. The combustion gases are drawn into the duct equipped with sensors to measurethe temperature, light attenuation, O2 and CO2 mole fractions and flow-induced pressure difference in the duct [5]. The SBI apparatus also consists of two identical burners to operate the furnace. The main (primary) burner is installed at the bottom corner of the trolley and it serves to expose the sample to fire, while the second burner is away from the specimen, fixed to a post of the frame. The general measurement equipment, also consists of three thermocouples type K, and one thermocouple type K for measuring the ambient temperature of the airflow inside.

Principle of testing

The first step is to calibrate the test apparatus and set the initial conditions prescribed in the standard SRPS EN 13823 [6]. When the two wings of the specimen are installed in the trolley, and the trolley is placed inside the test room, the test can begin. The test lasts 20 minutes, and during that time,the performance of the specimen is evaluated. The performance parameters are: heat production, smoke production, lateral (horizontal) flame spread, and falling flaming droplets and particles.

At 0 s test starts with the time measurement. After 120 s, the secondary burner ignite using propane gas. The time period between 210 s and 270 s is used to measure the baseline for the heat release rate (HRR). At 300 s, the secondary burner is turned off, and the primary burner is turned on using propane gas. In the next 1260 s, it is necessary to record the data. After 1560 s, the gas supply to the burner is cut off, and the automatic recording of data stops. The end of testing should not be beforefinishing the influence of remaining combustion. For each test, it is necessary to represent the burning behavior of the product (the average heat release rate – HRRav (t), total heat release – THR (t), the value for the fire growth rate – FIGRA0.2 MJ and FIGRA0.4 MJ, total heat release within 600 s – THR600 s), the smoke product behavior of the product (average smoke product SPRav (t), total smoke production TSP (t), index SMOGRA, total smoke production within 600 s – TSP600 s), and products of flaming droplets and particles using graphs. The criteria, for the SBI test method, that should be metfor the product to obtain the desired class are shown in the following tables. Also, it is necessary to perform minimum one other test method to obtain certain class.

Table 2 – Criteria for the SBI test

Class	Criteria
A2	$FIGRA_{0.2\,MJ} \leq 120$ W/s
	$THR_{600\,s} \leq 7.5$ MJ
B	$FIGRA_{0.2\,MJ} \leq 120$ W/s
	$THR_{600\,s} \leq 7.5$ MJ
C	$FIGRA_{0.2\,MJ} \leq 250$ W/s
	$THR_{600\,s} \leq 15$ MJ
D	$FIGRA_{0.2\,MJ} \leq 750$ W/s

Table 3 – Additional classes for the SBI test

Additional classes	Criteria
Smoke productions	
s1	$SMOGRA \leq 30\ m^2/s^2$
	$TSP_{600\,s} \leq 50\ m^2$
s2	$SMOGRA \leq 180\ m^2/s^2$
	$TSP_{600\,s} \leq 200\ m^2$
s3	it is neither s1 or s2
Droplets and particles	
d0	without flammable droplets and particles during the first 600 s
d1	occurrence of flammable droplets and particles that last longer than 10 s during the first 600 s
d2	it is neither d0 or d1

3. EXPERIMENT

For the purpose of the experiment, three identical samples of a facade system with mineral wool were tested. Façade systems were chosen for the experiment as the most complex multilayer structure. The sample represents an inhomogeneous multilayer facade system composed of the following layers:

- cement board thickness 15 mm,
- mortar for gluing thermal insulation boards thickness 7 mm with a percent of organicmaterials 2 % and mass per unit area of 6 kg/m^2,
- thermal insulation board made of mineral wool thickness 120 mm, density 135 kg/m^3,
- final facade layer.

The final facade layer consists of:

- mortar kit with an organic share of 2 % and surface mass of 6 kg/m^2,
- facade mesh, surface mass of 0,16 kg/m^2,
- reinforcement mortar with an organic share of 2 % and surface mass of 6 kg/m^2,
- primer with an organic share of 8,5 % and surface mass of 0,25 kg/m^2,
- final facade plaster with an organic share of 9 % and surface mass of 3 kg/m^2.

Before the test started, the specimen was conditioned at a temperature of 23 °C, in accordance with the standard SRPS EN 13238. Three standard tests were conducted, and the results are presented in the following table. Figure 2 shows the sample 1 at the beginning, at the middle and at the end of testing, while the graphs are presented in Figure 3.

Table 4 – Results of three testing

Parameter	Sample 1	Sample 2	Sample 3
THR$_{600\ s}$ [MJ]	2.221692	1.987236	2.857087
FIGRA$_{0.2}$ [W/s]	26.143056	28.556844	34.405483
FIGRA$_{0.4}$ [W/s]	26.143056	28.556844	34.405483
TSP$_{600\ s}$ [m^2]	0.312813	24.614913	0.648370
SMOGRA [m^2/s^2]	0	1.153114	0
LFS	no	no	no
Droplets and particles [s]	no	no	no

Figure 2 – Sample 1 at the beginning, at the middle and at the end of testing

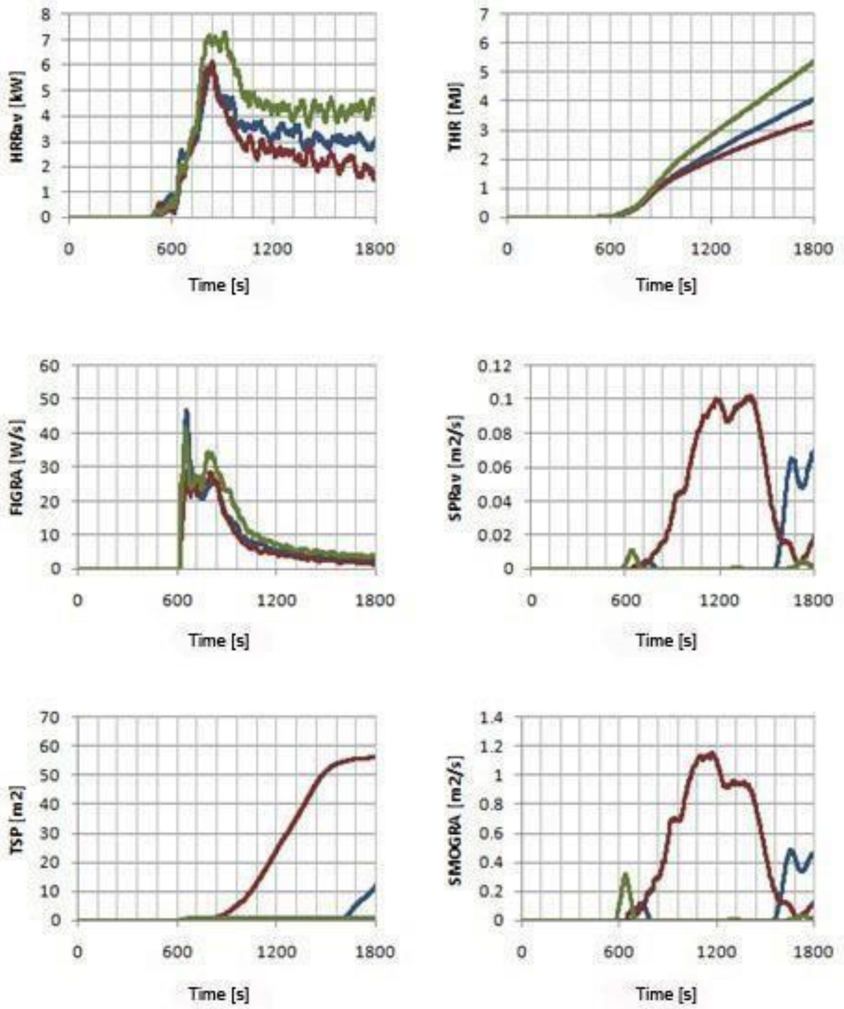

Figure 3 – Results of the SBI test represented as graphs

During the tests, no major changes were observed on the samples, using the visual technique. Throughout the test, there was no occurrence of sample leakage, or flaming droplets. The smoke production during the tests, were no significant. Results from the SBI test serve as input data to obtain the fire reaction class. The standard for SBI prescribes that input data must be averaged. According to the results from the Table 4 the average values are calculated and amounts:

- $THR_{600\ s}$ = 2.3553 MJ,
- $FIGRA_{0,2}$ = 29.7018 W/s,
- $FIGRA_{0,4}$ = 29.7018 W/s,
- TSP_{600s} = 8.5254 m^2,
- SMOGRA = 0.3844 m^2/s^2,
- LFS = no,
- droplets and particles = no.

Based on the calculated average values as well as the criteria prescribed by the standard [6], it was obtained that the value for FIGRA is much below 120 W/s, and the value for TSP600 s is much below 7.5 MJ, so the facade system can be classified as A2. The value for the SMOGRA was much below the 30 m^2/s^2, and the TSP600 s was much below the value of 200 m^2, so the product can be classified as s1. During the test there were no firing droplets and particles, so the product can be classified as d0. In order to confirm that the sample is class A2 it is necessary to perform one more test, that test, for this type of product is EN ISO 1182 (non-combustibility test) [7]. Even though the deviations shown on the graphs may appear significant, the obtained results for each of three tests, are below the criteria prescribed in the standard [6].

4. CONCLUSION

To determine the fire reaction class for a specific material, several tests need to be conducted. The most complex and sophisticated method is the SBI test. This is the reason why this particular method was chosen as the topic of this study. The purpose of this method is to define the basic thermal and smoke parameters that are later used for classification purpose.

The second part of the study pertains to the conducted experiment, focusing on a facade system with mineral wool. The facade system was chosen for the experiment because it represents the most complex case in terms of testing in Serbia at the moment. Three tests of identical samples (facade systems with mineral wool) were performed. After finishing all three tests and result processing, the results show the differences that are noticeable on the graphs. Although these deviations may appear significant, the samples demonstrated good repeatability. The reason for the variations lies in the nature and sophistication of the method itself. Therefore, the standard requires testing three identical samples, and the average value of the three results is used as input data for determining the fire reaction class. Moreover, the installation method of the sample also plays a significant role and can affect the final results. The people who participated in the writing of the standard [6] are aware of these facts and for this reason it is prescribed that three samples must be tested after which all results have to be averaged. After calculating the average values, it is shown that the facade system with mineral wool has fire reaction class of A2s1do. That means that this product, in a fully developed fire, does not increase the fire load or accelerate the spread of the fire.

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